The Soil Reactions of the Ferns of Woods and Swamps.

EDGAR T. WHERRY

The ferns to which this essay is devoted are on the whole less sensitive to soil acidity and alkalinity than those which grow on rocks, to which attention was directed in a previous paper.[1] It seems worth while, however, to place on record what data have been obtained on testing the soils surrounding their roots by the indicator method. The introductory and explanatory portions of the paper cited apply sufficiently well to the present one to make their repetition unnecessary. The data are presented in similar form, although a slightly different method of classification seems desirable, for additional types of reaction-range are represented. The following designations are used in the class column of table 1:

AA, intensely acid; appearing to thrive only in medi-acid soils.

A, acid; growing well in soils of practically all degrees of acidity.

I, indifferent (relatively); appearing to thrive in both acid and alkaline soils, so long as neither reaction is extreme.

C, calcareous or circumneutral; growing best in neutral soils, though extending throughout what is termed the circumneutral range (specific acidity 10 to alk. 10). No instance has been found of a species which will not grow in neutral or slightly acid soils as well as in actually alkaline ones.

In the last column the geographic range is described by S for southern, N for northern, and a dash,—,when the species is wide-ranging.

[1]Amer. Fern Journ., **10**: 15–22, 45–52, 1920.

TABLE I. SOIL REACTIONS OF FERNS OF WOODS AND SWAMPS.

Name	No. of Tests	REACTIONS									Class	Range
		Mediacid		Subacid		Minimacid		Minimalkaline		Subalkaline		
						Circumneutral						
		300+	100	30+	10	3+	1	3+	10	30+		
Schizaea pusilla	10	X	–	–	–	–	–	–	–	–	AA	S
Lygodium palmatum	10	X	x	–	–	–	–	–	–	–	AA	S
Osmunda regalis var. spectabilis	30	X	X	X	x	x	–	–	–	–	A	–
cinnamomea	30	X	X	X	x	x	–	–	–	–	A	–
Claytoniana	20	x	X	X	X	X	X	x	–	–	I	–
Pteretis nodulosa	20	–	–	–	x	X	X	X	x	x	C	N
Onoclea sensibilis	30	x	X	X	X	X	X	X	x	–	I	–
Dennstedtia punctilobula	30	x	X	X	X	X	X	X	x	–	I	–
Woodwardia areolata	20	X	x	–	–	–	–	–	–	–	AA	S
virginica	20	X	X	X	X	x	–	–	–	–	A	S
Pteridium latiusculum	30	X	X	X	X	x	–	–	–	–	A	–
Adiantum pedatum	30	–	–	x	X	X	X	X	x	–	C	–
Polystichum acrostichoides	30	x	X	X	X	X	X	X	x	–	I	–
Braunii	10	–	–	x	X	X	X	X	x	–	C	N
Athyrium angustifolium	10	–	–	x	X	X	X	X	x	–	C	–
acrostichoides	10	–	x	X	X	X	X	X	x	–	I	–
asplenioides	30	x	x	X	X	X	X	X	x	–	I	S
angustum	10	x	x	X	X	X	X	x	–	–	I	N
(Dryopteris = Aspidium; includes Phegopteris)												
Dryopteris Thelypteris	30	X	X	X	X	X	X	X	x	–	I	–
simulata	10	X	x	–	–	–	–	–	–	–	AA	S
noveboracensis	30	X	X	X	X	X	X	x	x	–	I	–
Linnaeana	20	–	x	X	X	X	X	x	–	–	I	N
Phegopteris	20	x	x	X	X	X	X	X	x	–	I	N
hexagonoptera	30	–	x	X	X	X	X	X	–	–	I	S
marginalis	30	–	x	X	X	X	X	X	x	x	I	–
Goldiana	10	–	–	–	x	X	X	x	x	–	C	–
var. celsa	10	X	–	–	–	–	–	–	–	–	AA	S
Filix-mas	(2)	–	–	–	–	–	X	X	–	–	C	N
cristata	20	x	X	X	X	X	X	X	x	–	I	–
var. Clintoniana	(2)	–	–	–	X	–	X	–	–	–	I	–
spinulosa	20	X	X	X	X	X	X	X	x	–	I	–
var. intermedia	20	X	X	X	X	X	X	X	x	–	I	–
var. americana	3	–	–	–	X	–	–	–	–	–	A	N
× Boottii	20	X	X	X	X	X	X	x	x	–	I	–
marg. × crist	10	–	–	x	X	X	X	x	x	–	C	–

Totals: AA, 5; A, 5; I, 18; C, 7; sum, 35.

FEATURES OF INDIVIDUAL SPECIES.[1]

The soils of the curly grass fern, *Schizaea pusilla*, have been tested at three localities in the New Jersey Pine Barrens, at all of which it grows in damp sand together with a short stemmed sphagnum. The reaction proved to be mediacid in all cases, and it is to be classed as a typical intensely-acid soil plant. Its relative the climbing fern, *Lygodium palmatum*, has been similarly studied in New Jersey and in Maryland just east of the District of Columbia, the same reaction being found. This plant is much more widespread than the curly grass, and may be tolerant of a somewhat less degree of acidity; but for the present both are placed in the same class.

The American royal fern, *Osmunda regalis* variety *spectabilis*, and the cinnamon fern, *O. cinnamomea*, are apparently identical in occurrence and soil requirements. They thrive best in sphagnum swamps, and tests of their soils there have shown, of course, high degrees of acidity. They also grow in damp woods where more or less leaf mold has accumulated, and tests of such localities in Pennsylvania and adjoining states have shown reactions ranging down to minimacidity. They are therefore classed as acid soil species. The interrupted fern, *Osmunda Claytoniana*, while found in the same general places as the two preceding, grows best in the leaf mold and is only exceptionally found in sphagnum. It is, moreover, abundant in calcareous glacial drift soils in northern New Jersey and Pennsylvania where the reaction has been found to reach a slight degree of alkalinity. It is accordingly classed as relatively indifferent.

[1]The nomenclature used here follows the 7th edition of Gray's Manual, with most of the changes urged by Mr. Weatherby (Rhodora, **21**: 173–179, 1919; also **22**: 80, 1920). In order to aid readers who do not have the literature at hand, and who of course will not find the new names in any previous text-book or other compilation on ferns, old and more or less well-known synonyms are added in many cases.

The ostrich fern, *Pteretis nodulosa* (formerly considered an *Onoclea*, then *Matteucia*) is best developed in alluvial soils and on damp limestone ledges, and its soil reaction does not vary much from neutrality. Near Lake Willoughby, Vermont, a subalkaline reaction was observed once, but minimalkaline was the rule. Along the Potomac river in Virginia just northwest of the District of Columbia it grows in sand kept nearly neutral in reaction by frequent inundation by the calcareous river water, and it does not spread far into the more acid upper levels. In its occurrence in the mountains of West Virginia the soil is very slightly acid, and it is regarded as a typical circumneutral soil plant. The sensitive fern, *Onoclea sensibilis*, is on the other hand a plant of wide reaction range. While not common in sphagnum swamps, it does grow in fairly acid soils; yet it seems to thrive just as well in limestone regions, where the waters are minimalkaline. It is accordingly placed in the indifferent class.

The hay-scented fern, *Dennstedtia punctilobula* (once classed as a *Dicksonia*) does not appear to have any marked preferences as to soil reaction. It often grows in sandy woods, although there thriving best on slopes where soils of somewhat diminished acidity approach the surface. It has even been observed in mediacid peat in the Dismal Swamp, in southern Virginia. On the other hand it grows on limestone ledges and in leaf mold accumulated on other rocks, where minimalkaline reaction may develop, and is to be regarded as a typically indifferent species.

The narrow-leaved chain fern, *Woodwardia areolata* (also known as *W. angustifolia*, and often placed in a different genus, *Lorinseria*) abounds in the New Jersey Pine Barrens, in sandy swamps east of the District of Columbia, in the Dismal Swamp, etc., where the reaction is almost uniformly mediacid. The same reaction

was found to characterize a swamp in the mountains north of Slatedale, Pennsylvania, where it was discovered, far from its usual Coastal Plain surroundings, by Mr. Harold W. Pretz. Experiments in the writer's garden have shown it to be readily killed by applications of calcareous (Potomac river) water. It is evidently an intensely-acid soil species. The broad-leaved chain fern, *Woodwardia virginica* (sometimes placed in the genus *Anchistea*) thrives best in mediacid sphagnum swamps and bogs, being in fact a pernicious weed in the cranberry bogs of southern New Jersey. It tolerates a decidedly lower degree of acidity than does the preceding species, however, having been observed in waters of as low as minimacid reaction in glacial drift near Allentown, Pennsylvania (Pretz), in the New Jersey Marl area and in the region around Cape Henry, Virginia. It is accordingly classed as merely an acid soil plant.

The common brake, *Pteridium latiusculum* (*Pteris aquilina* of old) grows in great abundance in the New Jersey Pine Barrens and elsewhere in the Coastal Plain sands, and might be supposed to be an intensely-acid soil plant. Its root system lies at a considerable distance beneath the surface, however, and is often surrounded by material of only moderately acid reaction. It seems quite definitely to avoid limestone, although in the vicinity of St. Johnsbury, Vermont, it has been observed to grow in calcareous glacial drift, of but minimacid reaction. It has also been found in the District of Columbia in red clay soils of this low acidity, and is to be classed as tolerant of all degrees of acidity.

The maiden-hair fern, *Adiantum pedatum*, thrives best where leaf mold of circumneutral reaction accumulates, and grows also in soils containing limestone fragments, exhibiting slight alkalinity. It appears to avoid the more acid soils, and is classed as a circumneutral

soil species. The writer has not had the opportunity to study the Venus' hair fern, *A. Capillus-Veneris*, in the field, but descriptions of its habitats indicate that it falls into the same class.

The Christmas fern, *Polystichum acrostichoides*, is about as nearly indifferent to soil reaction as a plant can be. It grows alike in the mediacid sands of the Coastal Plain, in decaying wood in the Dismal Swamp, in leaf mold, and in the alkaline soils over limestone ledges. The most luxuriant plants, however, appear in the soils of intermediate reactions. Braun's Holly fern, *P. Braunii*, seems to be rather more limited in its soil preference. It has been studied in the vicinity of Lake Willoughby, Vermont, and at its southernmost known station in Ganoga Glen, Luzerne County, Pennsylvania. In the former region the rocks are decidedly calcareous, and the soils neutral or slightly alkaline; in the latter locality the rock is a red sandstone, and the soils slightly acid. The plant thus falls into the circumneutral soil class.

The narrow-leaved spleenwort, *Athyrium angustifolium* (formerly classed as an *Asplenium;* also known as *A. pycnocarpon*) is most common in limestone regions, in practically neutral or somewhat alkaline soils. In Virginia just northwest of the District of Columbia it grows in neutral river sand, but also extends up the bank into soils of slightly acid reaction. On the whole, however, its relations suggest it to be a circumneutral soil species. The related silvery spleenwort, *Athyrium acrostichoides* (also formerly an *Asplenium;* once *A. thelypteroides*) is decidedly more wide-ranging, thriving in subacid soils as well as in minimalkaline ones; it is accordingly classed as indifferent.

The lady-fern group (*Asplenium Filix-Foemina* of old) has now been subdivided into two species, *Athyrium asplenioides* and *A. angustum*, which may perhaps be

best distinguished as the lowland and highland lady ferns respectively. The lowland species, which is common on the Atlantic Coastal Plain and on the Piedmont Plateau, has a very wide range of soil preference. In the extreme acid sands of the Coastal plain it does not thrive so well as in subacid soils; but it is decidedly luxuriant in limestone regions too. The highland lady fern, so called because it is best developed in the Allegheny Mountains and in the New England hills, is also rather wide ranging. Though apparently most luxuriant in practically neutral soils it was noted to grow all through the Presidential Range, White Mountains, New Hampshire, often well above the tree line, and extending almost to the summit of Mt. Washington. As the soils became more acid, on ascending these mountains, the fern became smaller in stature, and even where conditions as to moisture content, shade, etc., were apparently favorable, it did not seem to thrive. On the other hand, neither was it found to do well in calcareous glacial drift. Both of these species are classed as indifferent, although they and their varieties deserve further study.

The remaining ferns to be described all belong to the large genus or group of which the synonymy is shown in the table. The marsh fern, *Dryopteris Thelypteris*, is wide-ranging, growing about equally well in acid bogs and in meadows watered by limestone springs. It is classed as indifferent. The "Massachusetts fern," *D. simulata*, has been observed only in swamps in Maryland east and northeast of the District of Columbia, the soils being mediacid in all cases. Further study may show it to have a wider range, but for the present it may be classed as an intensely-acid soil plant. The New York fern, *D. noveboracensis*, is, however, about as wide ranging as the marsh fern, and is similarly classed.

The beech fern group, formerly placed in a separate genus *Phegopteris*, but now included under *Dryopteris*,

are all about alike in soil preference. The oak fern, *D. Linnaeana* (*Phegopteris Dryopteris*) has not been observed in the most acid soils, and thrives best in those of such low acidity, or even slight alkalinity that it is placed in the circumneutral soil class. The long beech fern, *D. Phegopteris*, is more wide ranging, growing, though greatly stunted, in the acid soils above the tree line on Mt. Washington, New Hampshire; being most luxuriant in glacial drift of very slightly acid reaction; but doing well even on limestone ledges. It is classed as indifferent. The broad beech fern, *D. hexagonoptera*, grows in a somewhat more restricted range of conditions, but does sufficiently well on both the acid and alkaline sides as to be placed in the same class.

The marginal-fruited fern, *D. marginalis*, grows on rocky slopes, and might have been included in the former paper (which treated of rock ferns). It is very wide ranging as far as reaction is concerned, though not observed in typically mediacid soils. A minimacid reaction seems to suit it best, but it also thrives in decidedly alkaline soil on limestone ledges, and it is classed as indifferent.

Goldie's fern, *D. Goldiana*, is a rather typical circumneutral soil plant, having been found in Virginia and Vermont in soils of at most minimacidity, in Maryland and Pennsylvania in minimalkaline limestone soils. The variety or subspecies known as *celsa* is on the other hand a plant of intensely-acid soils, growing most luxuriantly throughout the Dismal Swamp, Virginia, where mediacid reactions are practically universal.

The male fern, *D. Filix-Mas*, has not been studied by the writer in the field. In certain nurseries it thrives in minimacid soils, and the soil in which it grows in one source of their supply, the mountains of Colorado, has been found to be practically neutral. A soil sample kindly sent to the writer by Miss Nancy Darling from

the colony of this fern in Hartland, Vermont, proved to be minimalkaline. It is therefore classed as a circumneutral soil plant, although more tests should be made upon it.

The crested fern, *D. cristata*, has a decidedly wide range of soil reaction, growing rarely in the New Jersey Pine Barrens and in the Dismal Swamp, Virginia, in mediacid soils (though not really thriving there) and, at the other extreme, occurring on damp limestone ledges in eastern Pennsylvania. The most luxuriant plants the writer has seen were growing in the slightly acid muck along a stream flowing through mica-schist rock in Maryland northwest of the District of Columbia. It is classed as indifferent. The variety known as Clinton's fern, var. *Clintoniana*, has not been studied in the field, but there is no reason to doubt its essential similarity in soil requirements to the typical form. Samples of its soil kindly sent to the writer by Mr. C. A. Weatherby from a maple swamp in Avon, Connecticut, gave minimacid reactions; and one sent by Miss Inez A. Howe from St. Johnsbury, Vermont, proved to be neutral.

The spinulose fern, *D. spinulosa* and the variety *intermedia*, are as far as observed identical in soil requirements, both being wide-ranging. The typical form was observed above the tree line on Mt. Washington, New Hampshire, in mediacid soil; while in the calcareous soil regions of central Vermont it seemed to avoid the soil proper and grew on hummocks of decaying vegetable matter where the acidity was also high. It is common in the acid Dismal Swamp, Virginia. On the other hand it has been found in eastern Pennsylvania to grow on limestone ledges, where the soil reaches minimalkalinity, and can only be regarded as on the whole an indifferent plant. The variety *intermedia* is occasional in mediacid soil on the Coastal Plain and in

the mountains of eastern Pennsylvania, though growing, like the species, on limestone, and evidently to be classed as indifferent also. The var. *americana* (formerly known as *dilatata*)has been tested near Lake Willoughby, Vermont, and there appears to favor slightly acid soils.

Two of the hybrids of species of *Dryopteris* have been studied as to soil acidity, the so called Boott's fern, *D. Boottii*, in Vermont, Pennsylvania, and Maryland, and the well-marked hybrid between *D. marginalis* and *D. cristata* in Pennsylvania and New Jersey. The former grows on everything from sphagnum hummocks to limestone ledges, and is evidently indifferent. The latter, however, has not been observed in soil of greater acidity than subacid, and may provisionally be classed as a circumneutral soil plant.

In the article on rock ferns already referred to, it was remarked that further study would no doubt result in extending somewhat some of the ranges of reaction recorded; and it seems of interest to record here one instance of this. The ebony spleenwort, *Asplenium platyneuron*, was classified as a calcareous soil plant rather tolerant of acidity, but stated not to have been observed in typically mediacid soils. It has since been found to grow with remarkable luxuriance in mediacid decaying wood in the Dismal Swamp, Virginia. A capital X, if not a bold-face one, should accordingly be placed in the 300 column in the table on page 17 of that article. This species thus becomes the widest-ranging rock-fern thus far recognized, (though really a woods-fern at the most acid extreme). The class should be changed, to indifferent.

From the foregoing discussion it will be seen that the ferns of woods and swamps are on the whole less particular than the rock ferns as to their soil reactions; and in but a single case, *Dryopteris Goldiana* and its variety *celsa*, are closely related plants sharply contrasted in

optimum reaction. It is, however, noteworthy, that the peculiar relation found to exist among rock ferns,—the favoring of acid soils by southern species and of circumneutral soils by northern ones,—is likewise well marked in the present series of plants. As the same sort of relation appears to hold also with other plants than the ferns,—in particular with the native orchids,—it is sufficiently definite to justify inquiry into its probable origin.

Circumneutral reactions are shown by soils which either: contain considerable amounts of undecomposed carbonate minerals; are bathed by alkaline spring waters; or are so situated as to favor the accumulation of leaf mold. An acid reaction, on the other hand, tends to develop in soils which either: lack carbonate minerals; are exposed to the action of rain water so that basic constituents become leached out; or are so located that peat can accumulate.

In northern latitudes, or at high elevations, rocks disintegrate more rapidly than they decompose, and so, if the rocks at any locality thus situated contain suitable minerals in the first place, circumneutral soils may develop. Glacial deposits are especially likely to contain undecomposed carbonate minerals, which the ice has ground from rock ledges; and actual tests of the soils derived from such deposits, in Pennsylvania, New Jersey, and the New England states, have shown that even after exposure to the weather for many thousands of years, since the last ice-sheet retreated, sufficient quantities of undecomposed minerals are still present in many places to keep the reaction circumneutral.

The territory left bare by the retreat of the great ice-sheet must at first have presented an almost unbroken expanse of circumneutral soils, and the vegetation which first occupied it accordingly comprised only plants which thrive best in such soils. Although acid soils

have developed subsequently in many places, and permitted invasion by plants adapted to growth under acid conditions, a considerable number of the original occupants still persist, and are today classed as "northern" species.

In more southern regions, on the other hand, decomposition usually outstrips disintegration, so that soils containing undecomposed carbonate minerals are relatively rare. Except where limestone outcrops, or where leafmold accumulates, therefore, the dominant soil reactions are inclined to be acid, and the plants, established there since long before the glacial period, have become adapted to growth in such soils. The favoring of circumneutral soils by northern species, and of acid soils by southern ones, is thus connected with the geological history of the respective regions.

WASHINGTON, D. C.

More About Early Days of the American Fern Society.

C. E. WATERS.

In the second number of this JOURNAL for 1919, was an interesting article by E. J. Winslow on "Early Days of the Fern Society." It brought back a host of pleasant memories and made me feel like a historical character. Most historical characters did whatever they became notorious for a long time ago, and they are almost invariably dead ones.

It does seem like a long time since the summer of 1887 when, a boy just out of grammar school, I spent a summer in the Pennsylvania mountains east of Altoona. There a botanist friend showed me that it was possible to become acquainted with the ferns and wild flowers